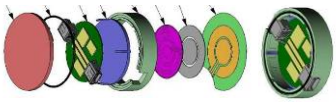
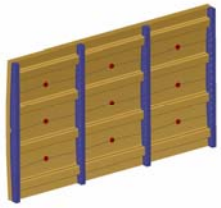


# Metis Design Corporation (MDC)

## Structural Health Monitoring (SHM) Capabilities Summary

SHM denotes the ability to detect and interpret adverse "changes" in a structure. Essentially, non-invasive detection devices are integrated into new or aging structures to continuously monitor components for damage. SHM is receiving increasing attention from the aerospace community because of its potential to eliminate scheduled manual inspections in lieu of condition-based maintenance (CBM). CBM increases design efficiency, and would enable more accurate component repair and replacement decisions. This methodology shift could result in a significant savings in the overall cost of ownership of a vehicle, as well as significant gains in operational safety.

**Sensors**

MDC has emerged as an industry leader for SHM, with a core competency in analytically-based sensor design. Through modeling of sensor physics, MDC has developed a series of tools to select optimized piezoelectric material properties, geometries and operating frequencies to detect damage by methods such as Lamb waves, modal analysis and acoustic emission. MDC has also tackled packaging issues, developing a protocol based on DO-160E, MIL-STD-810F and MIL-STD-461E that includes resistance to heat, moisture, pressure, vibration and chemicals.

**Hardware**

To successfully achieve SHM, appropriate hardware must be in place to facilitate testing. MDC has developed a series of robust sensor electronics to provide an infrastructure for a variety of SHM methods with little modification. Analog components of this infrastructure include optimized shielded electrodes and micro-connectors to provide strain-relief. The digital version integrates a microprocessor, 1MHz 16-bit A2D, 1MS/s function generator, memory and mini-USB or/or wireless chip within a 1" diameter, ¼" tall package. Variations of this hardware have been developed to meet custom geometries, support various sensors and increased sensitivity to particular damage modes.

**Software**

MDC has developed a complementary SHM software package to manage data collection, fusion, interpretation and dissemination. Based on robust proprietary algorithms, the software can detect miniscule "changes" in components and subsequently identify the presence, location, severity and type of damage with a very low probability of false positives. All MDC software includes a simple, user-friendly interface with customizable reporting capabilities.

**Systems**

To attain the benefits of SHM, a customized system must be developed for each class of vehicle. The experience of MDC engineers along with the flexibility MDC developed sensors, hardware and software allows the custom integration of SHM systems into state-of-the art vehicles as well as challenging aging aircraft applications. Considerations include an overall concept of operations, methods to employ, networking, and power constraints.

**Modeling**

Perhaps as important as the diagnostic capabilities of SHM are prognostic models. SHM data can be used within component progressive failure models to predict the effect of the detected damage, to estimate growth rates and usable remaining life of a component, and to guide the design of effective repairs. MDC engineers have extensive experience modeling both metals and composite material, which is necessary to capture all possible failure modes.

**Advantages**

There are several advantages to the MDC system over competing technologies. Principally, MDC uses a software-centric design allowing sensors and hardware to be mass-produced, using flexible software to customize the system to any application thereby reducing time, risk and cost. Also, MDC sensors are surface mounted, since embedded sensors can initiate damage, complicate repairs, and cannot be replaced. Surface mounted devices can also be more easily retrofitted onto ageing aircraft. Next, this system uses Lamb waves, which can efficiently query large areas than other methods, reducing sensor density, cost, weight, complexity and computational requirements. Finally, embedded logic within MDC hardware includes self-calibration, self-compensation and self-diagnostic capabilities.